

COAL REMINING
BEST MANAGEMENT PRACTICES
GUIDANCE MANUAL

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Section 7.0 Best Management Practices - Costs

Glossary and Acronyms

Abiotic: Pertaining to the absence of plant and animal activity or mode of living.

Acid-Forming Materials (AFMs): Rocks (enclosing strata) and processed mine wastes that have appreciable amounts of reactive sulfides. These sulfides are mainly iron disulfides in the form of pyrite and marcasite, and will oxidize and subsequently combine with water to produce acidity and yielding significant amounts of iron and sulfate ions.

Aerobic: A term used to describe organisms that only live in the presence of free oxygen. It is also used to describe the activities of these organisms.

Alkaline addition: The practice of adding alkaline-yielding material into a mine site where the overburden analysis indicates that there is a net deficiency of natural alkalinity. Alkaline material used to perform this task is commonly limestone, various lime wastes, or alkaline CCW.

Anaerobic: A term used to describe organisms that live in the absence of free oxygen. It is also used to describe the activities of these organisms.

Anoxic: An environment (gaseous or aqueous) with virtually no available free oxygen. Oxygen required for chemical reactions or for organisms is severely limited. Little or no chemical and biological activity that requires oxygen can occur. Water with less than 0.2 mg/L dissolved oxygen may be considered anoxic.

Anoxic Limestone Drains (ALDs): Drains composed of limestone that are constructed and covered to prevent the introduction of atmospheric oxygen to the system. Mine drainage is diverted through these drains to increase the alkalinity and without the armoring of the limestone by the iron in the water. The iron in the mine water must be in the ferrous state (Fe^{2+}) and the aluminum concentration must be relatively low in order for these systems to work properly over the long term.

Anionic surfactants: Any of a number of cleansing detergents that act as bactericides, thus inhibiting the presence of iron-oxidizing bacteria.

Anisotropic: A medium that exhibits different properties (e.g., hydraulic conductivity, porosity, etc.) in each direction measurement.

Anticline: A generally convex upward fold in sedimentary rocks where the rock in the core of the fold is older than those on the flanks. The opposite of a syncline.

Aquifer: A relatively permeable rock unit or stratigraphic sequence. Aquifers are saturated units that are permeable enough to produce economic quantities of water at wells or springs.

Aquifer tests: A variety of hydraulic tests conducted with the use of a well to determine porosity, permeability, and other properties of the rock unit tested. These tests usually involve the addition or removal of a measured volume of water or a solid with respect to time, while the response of the aquifer is measured in that well and/or other nearby wells.

Aquitard: Less permeable units in a stratigraphic sequence. These units are not impermeable, but only permeable enough to be important on a regional ground-water system basis. Wells in aquitards are not able to produce sufficient amounts of water for domestic or commercial use.

Auger mining: To extract coal from a highwall by drilling into the coal by the use of a horizontal augering equipment. This is employed when removal of additional (thicker) overburden is not economical.

Bactericide: Any of a number of materials that are used to kill bacteria, such as anionic surfactants.

Baseline: Pre-mining environmental conditions, specifically, pre-mining pollutant loading in pre-existing discharges. Baseline levels of pollutants can be used for comparison monitoring during mining activity.

Bench: This term can be used in at least two distinct contexts in regards to mining. First it can refer to a particular part of a coal seam split by a noncoal unit (e.g., shale, claystone), for example a “lower bench”. A second definition can refer to a land form where a nearly flat level area is created along a slope with steeper areas above and below.

Bentonite: An encompassing term for variety or mixture of clays (primarily montmorillonite) that swell in water. Bentonite is used commercially used as a sealant in wells and for creating low permeability barriers.

Best Management Practice (BMP): Relative to remining, and as used in this document, BMPs are mining or reclamation procedures, techniques, and practices that, if properly implemented, will (1) cause a decrease in the pollution load by reducing the discharge rate and/or the pollutant concentration, (2) reduce erosion and sedimentation control problems, and/or (3) result in improved reclamation and revegetation of abandoned mine lands.

Biosolids: A general term for the residual solid fraction, primarily organic material, of processed sewage sludge. A similar term is biosludge, which can be derived from other organic sources, such as paper mill waste.

Biotic: Pertaining to plant and animal activity and mode of living.

Bone coal: A relatively hard high-ash coal grading toward a carbonaceous shale, a high-organic content shale.

Buffer: The ability of a solution to resist changes in pH with the addition of an acid or a base.

Calcareous shale: A shale with a significant calcium carbonate content. The calcium carbonate content is sufficient to yield alkalinity with contact with ground water.

Carbonaceous: An organic-rich (carbon) rock, such as coal, “bone” coal, and organic-rich black shale.

Cast-blasting: A method of directional overburden removal blasting.

Check dam: An above grade structure placed bank to bank across a channel/ditch (usually with its central axis perpendicular to flow) for the purpose of controlling erosion. Check dams are commonly composed of rip rap, earthen materials, or hay bales.

Chimney drain: A highly transmissive vertical drain composed of large rock fragments that will intersect ground water coming in from the highwall or the surface and rapidly directing this water through and away from the main body of the mine spoil.

Claystone: A clay-rich rock exhibiting the some of the induration of shales, but without the thin layering (laminations) or fissility (splits easily into thin layers).

Coal Combustion Wastes (CCW): The residual material remaining from the process of burning coal for power generation and for other purposes. CCW includes fly ash, bottom ash, flue gas desulfurization wastes, and other residues. CCW may also include the by-product of limestone used for desulfurization during the combustion process.

Coal Refuse: The waste material cleaned from freshly-mined coal after it is excavated from the pit or brought from underground. Coal refuse is commonly composed of carbonaceous shale, claystone, bone coal, and minor to substantial amounts of “good” coal.

Confidence Interval: The range of values around a statistic (for example, the median) in which the true population value of the statistic occurs with a given probability (often 95 percent).

Culm: Term used in the anthracite district of Pennsylvania when referring to coal refuse.

Daylighting: To surface mine through abandoned underground mine workings by the removal of the overlying strata to access the remaining coal. Overburden removal exposes the remaining coal pillars.

Diagenesis: The chemical, physical, and biologic actions (e.g., compaction, cementation, crystallization, etc.) that alter sediments after deposition, exclusive of metamorphism and surficial weathering.

Dragline: A large crane-like type of earth moving equipment that employs a heavy cable or line to pull an excavating bucket through the material to be removed (overburden rock), thus filling it. The bucket is then lifted, moved away, and dumped.

Drawdown: The measured lowering of the water level in a well (or aquifer) from the withdrawal of water. It is reported as the difference between the initial water level and the level during or after the withdrawal.

Diversion ditch: A ditch engineered and installed to collect surface water runoff and transport it away from down gradient areas. These ditches are commonly installed to control runoff.

Evapotranspiration: The water loss from the land surface to the atmosphere caused by direct evaporation and transpiration from plants.

Exsolve: The process by which where two materials, such as a gas and a liquid, unmix. For example, when carbon dioxide (CO₂) comes out of solution from water into the atmosphere.

Geotextiles: Any of a variety of manufactured materials (e.g., plastic sheeting) that are used to prevent or impede the movement of ground water vertically or laterally or prevent erosion.

Ground-Water diversion well: A water well installed and designed to intercept and collect a significant amount ground water, thus preventing the ground water from reaching an undesirable area down gradient.

Grout curtain: A low or nearly impermeable barrier created in strata or fill by the use of pressure grouting via a series of injection wells. In theory, the fractures and other pore spaces are filled with a low permeability grout thus impeding ground-water movement.

Highwall: The highest exposed vertical face of the coal and overburden of a surface mine at any given time during mining. The final highwall is the maximum extent of surface mining.

Hummocky: Used to describe highly uneven topography, commonly composed of a series of small irregularly-rounded hills or hummocks.

Hydraulic conductivity: The flow rate of ground water through a permeable medium. The flow rate is given in distance over time (velocity), such as meters per second (m/s).

Hydrologic: Pertaining to ground and/or surface water systems.

Hydrologic unit: A term used to describe an area where infiltrating waters will drain to a point or a series of related points. The area is hydrologically distinct and isolated from adjacent hydrologic units.

Hydrolyze: Chemical reactions involving water, where H^+ or OH^- ions are consumed in the process.

Hydrothermal: Chemical and physical activity pertaining to hot ground water associated with underlying igneous activity.

Induced Alkaline Recharge: Systems installed in surface mines to introduce recharge of alkaline charged waters to treat or abate the production of acid mine drainage. Surface water is diverted to where it contacts trenches or “funnels” filled or lined with alkaline rocks (e.g., limestone). These trenches are closed systems that induce this water to infiltrate and recharge the spoil.

Infiltration: The downward flow of water into the land surface through the soil or lateral ground-water flow from one area to another.

Interaction: The effect of a variable (for example, the presence or absence of a BMP) on a variable of interest (for example, the change in a discharge) is significantly effected by a third variable (for example, the presence or absence of another BMP).

Interfluves: Regions of higher land lying between two streams that are in the same drainage system.

Logistic Regression Model: A statistical method of evaluating the relationship between one or more variables on a variable with a discrete (countable) number of outcomes.

Lowwall: A exposed vertical face of the coal and overburden generally representing the lowest cover to be encountered. Common to mines where the coal is not mined completely out to the coal outcrop and frequently spatially opposite to the location of the highwall.

Metamorphic: The mineralogical, chemical, and structural alteration of buried sediments and rock from heat and pressure.

Mine spoil: Overburden strata (rock) broken up during the course of surface mining and replaced once the coal is removed. Particle sizes in the backfill (spoil) range from clay-size to those exceeding very large boulders.

Odds: The probability of an event occurring divided by the probability of an event not occurring.

Odds ratio: The odds of an event occurring divided by the odds of a second event occurring, used to compare how likely two different events are.

Oxic: An environment (gaseous or aqueous) with readily available free oxygen (oxygen not limited for typical chemical reactions or for organisms that require it).

Oxic Limestone Drains: These are limestone drains that are partially open to the atmosphere. These drains induce elevated CO₂ concentrations to build up, which in turn causes an aggressive limestone dissolution and alkalinity production, thus preventing armoring from the iron in the water.

Open Limestone Channels: These are limestone drains that are open to the atmosphere. Some research has indicated that even armored with iron these drains may impart 20 percent of the alkalinity that unarmored limestone will yield.

Outcrop: The exposure where a specific rock unit intersects the earth's surface. The outcrop can be covered with a thin layer of surficial material such as colluvium.

Parting: A noncoal unit that commonly separates parts (benches) of a coal seam. Parting rock commonly consists of shale, claystone, or bone coal. Sometimes called a binder.

Passive treatment: Methods of mine drainage treatment requiring minimal maintenance after the initial installation. Passive treatment systems include but are not limited to aerobic and anaerobic wetlands, successive alkaline producing systems, and anoxic limestone drains.

Permeability: The ability of a rock or sediment to transmit a fluid (e.g., water). It is directly related to interconnectedness of the void spaces and the aperture widths.

Pillar: A solid block of coal remaining after conventional underground mining (room and pillar) mining has occurred.

Piping: The action of substantial volumes of ground water transporting fine-grained sediments through unconsolidated materials, such as mine spoil, leaving large conduits or voids in the process.

Pit Cleanings: Noncoal material (e.g., seat rock, roof rock or parting material) separated from the saleable coal at the mine pit. This material commonly contains elevated sulfur values and is usually potentially acid producing.

Pit floor drains: As the name implies, these are drains that are installed in or along the pit floor to collect and rapidly transmit ground water through and away from the spoil. They are commonly constructed of perforated drain pipe covered in limestone or sandstone gravel.

Pore gas: Gases located and stored in the interstitial or pore spaces in soil, spoil, or other earthen materials above the water table.

Porosity: The ratio of open or void space volume compared to the total volume of rock or sediment. Commonly given in units of percent.

Pozzolonic: A property of a material to be, to some degree, self-cementing.

Pre-existing discharge: Pollutational discharge resulting from mining activities prior to August 3, 1977 and not physically encountered during active mining operations. Under the Rahall Amendment to the Clean Water Act, a pre-existing discharge is defined as any discharge existing at the time of permit application.

Probability: On a scale of 0-100, how frequently a given event (for example, a discharge improving) would occur.

Pyrolusite® systems: A large open limestone bed that mine water is allowed to slowly pass through. The system is inoculated with “specially developed bacteria” to promote the formation pyrolusite (an manganese oxide), thus removing manganese from solution. More recent research indicates that the mineral formed is todorokite (a hydrated manganese, calcium, magnesium oxide) and the bacteria that aid this mineral formation most likely exist within the system naturally without inoculation.

Remining: Surface mining of abandoned surface and/or underground mines for which there were no surface coal mining operations subject to the standards of the Surface Mining Control and Reclamation Act. Remining operations implement pollution prevention techniques while extracting coal that was previously unrecoverable.

Rill: Small erosional gully or channel created by runoff.

Rip rap: Materials (rock, cobbles, boulders, straw) placed on a stream bank, ditch or filter as protection against erosion.

Rivulet: A small stream or streamlet that develops from rills, commonly located on steep slopes.

Sample Median: In a set of numbers, the value where the number of results above and below the value are equal.

Scarification: The act of making a series of shallow incisions into the pit floor, topsoil, or other surface to loosen or break up the material to foster beneficial actions, such as exposure of alkaline material or promote plant growth.

Seep: A low-flowing surface discharge point for ground water. A low-flow spring.

Shoot and shove mining: A pre-SMCRA mining method that involved shooting or blasting the overburden and pushing (shoving) it down the hillside. This type of operation was most common in steeply-sloped regions, and resulted in abandoned highwalls, exposed pit surfaces, and steep abandoned spoil piles below the mine.

Shotcrete: A mixture of portland cement, water, and sand that can be pumped under pressure applied (sprayed) via a hose. It is commonly used for sealing in underground mines and for surface features, such as streams. Also called gunite.

Special handling: A process where potentially acidic or alkaline material is segregated (stockpiled) during surface mining and selectively placed during reclamation in lifts or pods the backfill with respect to the projected post-mining water table and/or the final ground surface.

Spoil swell: The increase in volume exhibited by mine spoil over the original volume the material prior to mining. Swell values can approach 25 percent in some regions.

Stemming: Inert material placed in blast holes above and between the explosive material to confine the energy of the explosion and maximize the breaking of the rock.

Stoichiometric: Used to describe the proportions of elements that combine during, or are yielded by, a chemical reaction.

Stress-relief fractures: Fractures in rock which form at relatively shallow depths caused by relaxation from the removal of the overlying rock mass from erosion. The retreat of glaciers in the northern Appalachian Plateau also may have aided the formation of these fractures. They are most common at depths of 200 feet or less.

Subaerial: Used to describe processes or resulting conditions from exposure to the atmosphere at or near the land's surface.

Suboxic: An environment (gaseous or aqueous) with very low concentrations of free oxygen. The levels are not low enough to be considered anoxic, but are suppressed to the degree that chemical and biological activity are controlled and attenuated.

Successive Alkaline Producing System (SAPS): A series of passive treatment systems that mine water is passed through by which alkalinity is imparted from sulfate reduction and limestone dissolution.

Syncline: A generally concave upward fold in sedimentary rocks where the rocks in the core of the fold are younger. The opposite of an anticline.

Tipple refuse (cleanings): The waste material left after raw coal is run through a “cleaning plant”. It usually has an elevated sulfur content.

Turbulent flow: Flow characterized by irregular, tortuous, and heterogeneous flow paths.

Vadose zone: Zone of aeration above the water table, unsaturated zone.

Water year: According to the United States Geological Survey (USGS) a water year occurs between October 1 and September 30.

Acronyms and Abbreviations

ABA: acid-base accounting

AFM: acid-forming material

ALD: anoxic limestone drains

AMD: acid mine drainage

AML: abandoned mine land

AMLIS: Abandoned Mine Land Inventory System

AOC: approximate original contour

ASTM: American Society for Testing and Materials

BAT: Best Available Technology Economically Achievable

BMP: Best Management Practice

BPJ: Best Professional Judgement

BPT: Best Practicable Control Technology

C: centigrade

CCW: coal combustion wastes

CFR: Code of Federal Regulations

cfs: cubic feet per second

CWA: Clean Water Act

cm: centimeter(s)

DO: dissolved oxygen

DOE: Department of Energy

ENR: Engineering News Record

EPA: Environmental Protection Agency

EPRI: Electric Power Research Institute

FIFRA: Federal Insecticide, Fungicide and Rodenticide Act

fps: feet per second

FRP: Federal Reclamation Program

gdm: grams per day per meter squared

GIS: Geographic Information System

gpm: gallons per minute

IMCC: Interstate Mining Compact Commission

L/min: liters per minute

lbs/day: pounds per day

lbs/ft³: pounds per cubic feet
mg/L: milligrams per liter
MPA: maximum potential acidity
m/s: meters per second
mt: metric tonnes
NNP: net neutralization potential
NP: neutralization potential
NPDES: National Pollutant Discharge Elimination System
NSPS: New Source Performance Standards
OBA: overburden analysis
OLD: oxic limestone drain
OLC: open limestone channel
OSMRE: Office of Surface Mining and Reclamation Enforcement
PA DEP: Pennsylvania Department of Environmental Protection
ppt: parts per thousand
psi: pounds per square inch
PVC: polyvinyl chloride
RAMP: Rural Abandoned Mine Program
RUSLE: Revised Universal Soil Loss Equation
SAPS: successive alkalinity-producing systems
SLS: sodium lauryl sulfate
SMCRA: Surface Mining Control and Reclamation Act
SOAP: Small Operator Assistance Program
SOS: Standard of Success
TCLP: Toxicity Characteristic Leaching Procedure
TMAT: Total Mined Area Triangle
TSS: total suspended solids
TVA: Tennessee Valley Authority
USBM: United States Bureau of Mines
USDA: United States Department of Agriculture
USGS: United States Geological Survey
USLE: Universal Soil Loss Equation
WPA: Works Progress Administration

Executive Summary

Purpose

This manual was created to support EPA's proposal of a Remining subcategory under existing regulations for the Coal Mining industry. The purpose of this guidance manual is to assist operators in the development and implementation of a best management practice (BMP) plan specifically designed for a particular remining operation. This guidance manual also was developed to give direction to individuals reviewing remining applications and associated BMP plans. This document is not intended as a substitute for thoughtful and thorough planning and decision making based on site-specific information and common sense.

Organization

This manual is organized to function as a user's guide to meet remining plan requirements and to improve abandoned mine land conditions during remining operations. The manual is divided into the following sections:

- Introduction - presenting state-specific abandoned mine land conditions, industry profile information, the status of remining operations, and general information regarding remining BMPs; the scope of pre-Surface Mining Control and Reclamation Act (SMCRA) mining and associated acid mine drainage contamination
- Sections 1.0 through 5.0 - describing hydrologic, sediment and geochemical control BMP implementation practices, site assessment required to determine implementation of these practices, implementation guidelines, design considerations, and case studies;

- Section 6.0 - detailing the efficiency of remining BMPs in regards to the water quality of pre-existing discharges;
- Section 7.0 - providing BMP implementation unit cost information;
- Appendix A - presenting EPA Coal Remining Database and including summary data and information from 61 state remining and abandoned mine land (AML) project data packages;
- Appendix B - presenting summary data from the Pennsylvania Remining Study of 112 closed remining operations affecting 248 pre-existing discharges; and
- Appendix C - presenting responses to the Interstate Mining Compact Commission (IMCC) remining solicitation sheet from 20 member states.

Details of the contents of each section are provided in the Section Outline.

Limitations

This manual provides information on many hydrologic and geochemical control BMPs which can be used to prevent or reduce pollution loading from abandoned mine lands during remining operations. This manual describes the best management practices and controls, provides guidance on how, when, and where to use them, and recommends maintenance procedures. However, the effectiveness of these controls lies fully in the hands of those individuals responsible for site operations. Although specific recommendations are offered in the following chapters, careful consideration must be given to selecting the most appropriate control measures based on site-specific features and conditions, and on properly installing the controls in a timely manner. Finally, although this manual provides guidelines for maintenance, it is up to the responsible party to make sure controls are carefully maintained or they will prove to be ineffective.

This manual is not intended as a stand-alone document in terms of BMP plan development and implementation. Additional information sources pertaining to remining and various aspects of

BMPs can and should be consulted. Many of these information sources are referenced throughout this guidance manual. This manual is intended for use by individuals with the background or experience to adequately understand the technical aspects detailed herein. Those individuals charged with developing, reviewing, implementing, and enforcing remining BMP plans, must be knowledgeable of all aspects of remining operations (e.g., hydrology, geochemistry, mining operations, etc.), and must be able to modify them when appropriate.

Results Summary

Review of existing data and information that was used to prepare this document indicates that remining operations accompanied by proper implementation of appropriate BMPs is highly successful in reducing the pollution load of mine drainage discharges. The information also shows that remining BMPs typically are used in combination as part of an overall and site-specific BMP plan. Critical to the effectiveness of a BMP plan in terms of water quality and AML improvement is that the plan is well designed and engineered, implemented as proposed, and that the implementation and subsequent post-mining results are verifiable.

